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(54) Title: METHOD FOR GENERATING A SECURITY DOCUMENT
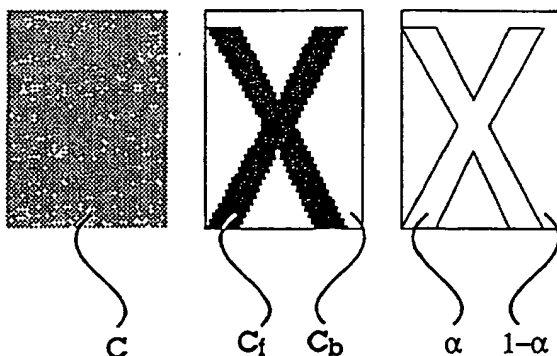
(57) Abstract: The described method is used for generating a security document by applying a security pattern to an original image. The security pattern comprises a plurality of points, wherein each of said points represents a pattern value. Local averages are calculated from said pattern values for at least some areas of the security pattern. For at least some of the points of the security pattern the color of the corresponding point of the original image is replaced by a modified color. The modified color is a function of the local average, the original color and the corresponding pattern value. The method provides good security against counterfeit because it is difficult to implement using conventional image processing applications. For a suitable choice of the color transformation function, the resulting image can preserve the local color tones of the original image.
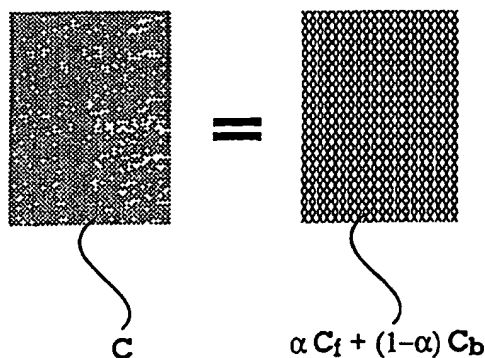
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method for generating a security document

Cross References to Related Applications

This application claims the priority of the
European patent application No. 99114740.6, filed on July
28, 1999, the disclosure of which is incorporated herein
by reference in its entirety.

Technical Field

The present invention relates to a method for
generating a security document and to a security document
obtained by this method according to the preamble of the
independent claims. In particular, it relates to the
field of security printing, and more particularly it re-
lates to anti-counterfeiting measures for identity docu-
ments showing a photograph of their holder.

Background Art

Many identity documents bear a photograph of
the document holder, because this photograph offers a
convenient way of relating the document to its owner. The
development of plastic card printers and the advances in
digital imagery have lead to the widespread use of iden-
tity documents printed on plastic cards, such as ID
cards, driving licenses and access key cards.

With the advance of color printers and copi-
ers, it has become easy to forge such documents unless
they are provided with security features, such as digital
watermarks, microscopic text, etc. Such security features
are, however, difficult to apply or to verify and they
often impair the overall appearance of the document.

Disclosure of the Invention

Hence, it is a general object of the invention to avoid at least part of these disadvantages. This
5 object is achieved by the subject-matter as set forth in the independent claims.

Hence, at least some of the points of the original image are modified by changing their color. The change of color is a function of the original color c_{ij},
10 of the value p_{ij} of a security pattern as well as of a local average α_k of the pattern. By using a function that depends on a local average of the pattern, it becomes possible to generate very flexible security markings that take the pattern's features into account. The protected
15 image is difficult to imitate by using commercial image-processing packages because the changes in the protected image do not occur along a fixed direction of the color space, but vary according to the color of the original image pixels and the averages of the security pattern.

20 The embedded pattern can e.g. be textual information already present elsewhere on the document, or it can be a code derived from data specific to the document holder. The protection can be made fully apparent, partly apparent, or completely invisible under normal
25 viewing conditions.

In a preferred aspect of the invention, a chromatic shift is given for any color of the original image. This shift is defined by the two colors that are used when the pattern value takes its minimum and maximum
30 values. In this case, the function f can e.g. consist of a linear interpolation between the two colors of the chromatic shift.

The chromatic shift can be derived from a reference shift at one specific color K. Preferably, a
35 correcting offset is applied to this reference shift for balancing it according to the local average α_k of the pattern. The chromatic shift can be calculated by cor-

recting the luminance, hue and saturation of the reference shift (or the corrected reference shift). A further possible correction adjusts the values of the chromatic shift to make its CIE-Lab luminance difference equal to

5   the one of the reference shift, which results in a uniformly contrasted pattern for any original color value.

The protected image is difficult to reproduce through photo-mechanic means such as a photocopying device, because the chromatic shifts it contains can be

10   specified as quasi-metameric pairs of colors. Either the pairs of colors are perceived as identical by the device and the embedded information is completely lost, or the pairs of colors are perceived as being more different than they really are and the embedded information becomes

15   much more visible under normal light than it is in the protected image.

Identity documents containing images with embedded text are even more difficult to forge, because the embedded text can contain an encrypted version of the

20   personal information present elsewhere on the document. Without knowledge of the process used for encrypting the text, it is impossible to adapt an existing document to a fake identity by replacing the photograph and the personal information.

25   The invention is especially suited for marking identity documents, such as driver's licenses.

Further preferred features and embodiments are described in the dependent claims.

30

Brief Description of the Drawings

The invention will be better understood and objects other than those set forth above will become ap-

35   parent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings, showing in

Fig. 1 a single character and its correspond-
ing gray level (top row) as well as the equality of two
areas having the same local average,

Fig. 2 the LEF color space,

Fig. 3 a bitmap pattern for a given string,

Fig. 4 the calculation of the average value
for a letter bitmap,

Fig. 5 the balancing of the reference shift,

Fig. 6 the assembly of a text into its pat-
tern,

Fig. 7 the repetitive arrangement of the pat-
tern of Fig. 6,

Fig. 8 the repetitive arrangement of the pat-
tern of Fig. 7,

Fig. 9 the staggering of the pattern on Fig.
8,

Fig. 10 the individual balanced reference
shifts of differing letters,

Fig. 11 the horizontal interpolation of the
reference shifts,

Fig. 12 the vertical interpolation of the
reference shifts,

Fig. 13 the luminance correction,

Fig. 14 the hue correction,

Fig. 15 the saturation correction, and

Fig. 16 the overflow correction.

Modes for Carrying Out the Invention

A preferred embodiment of a method that pro-
tects identity documents by embedding text into photo-
graphs is described hereafter. The method consists of the
following basic steps: A reference chromatic shift (the
"reference shift") is specified in a linear color space.
Each character of the text to embed is rasterized into a
bitmap. The reference shift is corrected for obtaining a

coverage-balanced chromatic shift ("corrected chromatic
shift") derived for each rasterized character according
to the ratio between the surface occupied by black pixels
(foreground) and the surface occupied by white pixels

5 (background); i.e. according to a local average of the
security pattern. The rasterized character string is re-
peated horizontally and vertically to form a security
pattern. A pattern-relative chromatic shift is interpo-
lated between the coverage-balanced chromatic shifts of

10 the neighboring bitmap characters for each pixel in the
security pattern. A chromatically shifted color is ex-
trapolated from the pattern-relative chromatic shifts for
each pixel of the original image. The protected image is
generated and output on a continuous-tone printer. De-

15 pending on the size and orientation of the reference
chromatic shift, the embedded text in the protected image
can be visible or invisible under normal viewing condi-
tions.

20   Chromatic shifts:
           · A "chromatic shift" is defined as a set of
three colors C, C_b and C_f such that a surface of unitary
area colored with C is visually equivalent to the same
surface split in two foreground and background parts of

25 area α, resp. $1 - \alpha$, with the foreground having color C_f
and the background having color C_b (Fig. 1). Mathemati-
cally, the colors of a chromatic shift must verify the
relation $C = \alpha\, C_f + (1 - \alpha)\, C_b$. C represents the refer-
ence color, C_b represents the reference background color,

30 and C_f represents the reference foreground color.
           An additive color space is used for specify-
ing the colors of a chromatic shift. Preferably, this
color space is obtained by a linear transformation of the
cube formed by the RGB space. The transformation and its

35 inverse are defined by the following equations:

$$
\begin{bmatrix} L \\ E \\ F \end{bmatrix} = \begin{bmatrix} \dfrac{2}{3} & \dfrac{2}{3} & \dfrac{2}{3} \\ 1 & -\dfrac{1}{2} & -\dfrac{1}{2} \\ 0 & \dfrac{\sqrt{3}}{2} & -\dfrac{\sqrt{3}}{2} \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} \dfrac{1}{2} & \dfrac{3}{2} & 0 \\ \dfrac{1}{2} & -\dfrac{1}{3} & \dfrac{1}{\sqrt{3}} \\ \dfrac{1}{2} & -\dfrac{1}{3} & -\dfrac{1}{\sqrt{3}} \end{bmatrix} \cdot \begin{bmatrix} L \\ E \\ F \end{bmatrix} \quad (1)
$$

After transformation, the RGB cube stands on
its black corner (Fig. 2). Its black-white axis is verti-
5   cal and becomes the L-axis in the newly defined LEF color
coordinate space. The two other E and F orthogonal axes
are lying in the plane perpendicular to the L-axis
through point L = 0 (the EF-plane). The E-axis goes
through the projection of vertex R of the RGB cube on
10   plane EF. The vertical L component can be assimilated to
the achromatic value of a given color, i.e. its luminance
level. The E and F components convey the chromatic infor-
mation pertaining to that color.

15   Choosing the reference shift:
The reference shift {K, K_b, K_f} for an arbi-
trary color K is specified by an interactive color pick-
ing application according to N. Rudaz, R. D. Hersch, V.
Ostromoukhov, Specifying color differences in a linear
20   color space (LEF), Proceedings of the IS&T/SID 97,
Scottsdale, 1997, pp. 197-202.

Creating a partial security pattern:
The string of characters forming the text to
25   embed into the image is converted into a bitmap image
through the use of a font rendering software component.
Suitable types of font renderers are known to a person
skilled in the art and are e.g. described in R.D. Hersch,
"Font Rasterization, the State of Art", in "Visual and
30   Technical Aspects of Type", Ed. R.D. Hersch, Cambridge
University Press, 1993, pp56-63.. An example of a font
renderer is the FreeType engine described at the URL
http://www.freetype.org/intro.htm.

The font rasterizer creates a rectangular bitmap for each character in the string of text (Fig. 3), which will form part of the security pattern.

5   Local averaging:

In the case of a binary bitmap, local averages α_k, defined as the black coverage percentage, are calculated for each character bitmap. α_k lies between 0 and 1; it is defined as the ratio between the number P_k

10   of foreground pixels and total number P_t of pixels or, in other words, if a pattern value p_{ij} of 1 is assigned to the foreground pixels and a pattern value p_{ij} of 0 to the background pixels, α_k corresponds to the average of the pattern values (Fig. 4).

15

Correcting the reference shift:

A coverage-balanced chromatic shift $\{K, K_b', K_f'\}$ is derived from the reference shift $\{K, K_b, K_f\}$ for each character bitmap. The chromatic distance $D = K_b - K_f$

20   is computed. An offset d is derived from D using the relation

$$d = D \cdot (\alpha_k - (p_{max} - p_{min})/2)/(p_{max} - p_{min}),$$

wherein p_{min} and p_{max} are the largest and smallest possible pattern values (for binary patterns we usually have

25      $p_{max} = 1$ and $p_{min} = 0$).

This offset d is added to K_b and to K_f in order to obtain K_b' and K_f' (Fig. 5):

$$K_b' = K_b + d, \qquad\qquad (2)$$
$$K_f' = K_f + d$$

30   The resulting coverage-balanced chromatic shift $\{K, K_b', K_f'\}$ exhibits the property that, if the white pixels of the associated character bitmap are colored with K_b' and the black pixels with K_f', then the average color of the character bitmap is equal to K.

8

Generating the security pattern:

The rasterized characters are horizontally juxtaposed into a rectangular tile (Fig. 6). This tile is horizontally repeated side by side as many times as nec-
5 essary in order to produce a second bitmap with the same width as the original image (Fig. 7). The second bitmap is vertically replicated side by side as many times as necessary in order to produce a third bitmap image with the same height as the original image (Fig. 8). At each
10 vertical repetition, the second bitmap is shifted hori- zontally in order to avoid disturbing optical artifacts that appear when characters are vertically aligned in a text. After the horizontal shift, the portion of the sec- ond bitmap that goes beyond the horizontal boundaries of
15 the original image is wrapped around (Fig. 9). This third bitmap is referred to as the security pattern and consti- tutes an image of the text that will be embedded into the original image.

20 Calculating the pattern-relative chromatic shifts:

A pattern-relative chromatic shift is com- puted for every pixel of the security pattern, based on the coverage-balanced chromatic shifts associated with the character bitmaps.
25 In a first step, every pixel of the security pattern that is located at the center of a character bitmap is associated with that bitmap's coverage-balanced chromatic shift (Fig. 10).

In a second step, every pixel of the security
30 pattern that is located on a horizontal line segment joining two centers of the character bitmaps is associ- ated with a pattern-relative chromatic shift that is ob- tained by linear interpolation between the coverage- balanced chromatic shifts associated with these two cen-
35 ters (Fig. 11).

In a third step, every pixel of the security pattern that is located on a vertical line segment join-

ing two pixels processed during the second step is asso-
ciated with a pattern-relative chromatic shift that is
linearly interpolated between the pattern-relative chro-
matic shifts of these two pixels (Fig. 12).

5   In a fourth step, every pixel of the security
pattern that has not been processed during the previous
steps is associated with the pattern-relative chromatic
shift of its nearest neighbor.

10   Calculating the chromatic shift:

           Each pixel in the security pattern is associ-
ated with a pixel having the same coordinates in the
original image. The pattern-relative chromatic shift un-
dergoes a geometrical transformation in the LEF color

15 space, with the purpose of adapting its background and
foreground colors (K_b' and K_f'), so that the color re-
sulting from the average α_k of the adapted background and
foreground colors is equal to the color $C_{ij} = (L_C, E_C,$
$F_C)$ of the associated original pixel.

20   In a first step, the luminance of the chro-
matic shift is corrected according to the luminance dif-
ference between the reference color K and the color C_{ij}.
For this purpose, the luminance difference ΔL_{CK} between
C_{ij} and $K = (L_K, E_K, F_K)$ is computed using the relation

25          $$\Delta L_{CK} = L_C - L_K,\qquad\qquad\qquad (3)$$
and this luminance difference is added to K', K_b' and K_f'
in order to obtain the colors K'', K_b'' and K_f'' (Fig.
13).

           In a second step, the hue of the chromatic
.30 shift is corrected according to the hue difference be-
tween the reference color K and the color C_{ij}. For this
purpose, the angular hue difference (ΔH_{CK}) between C and
K'' is computed using the relation

           $$\Delta H_{CK} = \mathrm{Tan}(\mathrm{Arctan}(F_C/E_C) - \mathrm{Arctan}(F_K''/E_K'')),\qquad (4)$$
35 and this angular hue difference is added to K'', K_b'' and
K_f'' in order to obtain the colors K''', K_b''' and K_f'''
(Fig. 14).

In a third step, the saturation of the chromatic shift is corrected according to the saturation difference between the reference color K and the color C_{ij}. For this purpose, the saturation difference (ΔS_{CK}) between C and K''' is computed using the relation

$$\Delta S_{CK} = \text{sqrt}((F_K''' - E_C)^2 + (E_K''' - E_C)^2), \qquad (5)$$

and this saturation difference is added to K_B''' and K_F''' in order to obtain the colors C_b and C_f (Fig. 15).

In a fourth step, the CIE-Lab luminance difference between C_b and C_f is adjusted so that it is equal to the CIE-Lab luminance difference between K_b and K_f while maintaining the balanced average of C_b and C_f at color C_{ij}

In a fifth step, the colors C_b and C_f are examined to see if they fit in the RGB color space. If this is not the case, the distance between C_b and C_f is proportionally reduced until both colors fit entirely into the RGB space (Fig. 16).

Applying the chromatic shift:

In a sixth step, the value p_{ij} of the security pattern pixel associated with the original image pixel is examined. If this pixel is white (e.g. corresponding to $p_{ij} = 0$), and therefore belongs to the background of the security pattern, then the color C_b is assigned to the pixel of the original image. If this pixel is black ($p_{ij} = 1$), and therefore belongs to the foreground of the security pattern, then the color C_f is assigned to the pixel of the original image. In general, for non-binary security patterns, the new color C_{ij}' is calculated from

$$C_{ij}' = C_b(C_{ij}) \cdot (p_{ij} - p_{min})/(p_{max} - p_{min}) + \qquad (6)$$
$$C_f(C_{ij}) \cdot (p_{max} - p_{ij})/(p_{max} - p_{min}),$$

where p_{min} and p_{max} are the minimum and maximum possible pattern values p_{ij}.

Printing the modified image:

The modified image is output on a continuous-tone printer such as a dye-sublimation printer. Dithering devices that apply halftone screens on the images they print, such as laser printers or ink-jet printers, are not suitable for printing the protected images because the dithering process alters the structure of the embedded text.

Detection of the embedded text:

If the reference shift {K, K_b, K_f} presents a large enough contrast, the embedded text is readable under normal viewing conditions. Conversely, if the reference shift {K, K_b, K_f} presents a weak contrast, the embedded text is invisible and a close inspection or image analysis is required in order to read it.

Remarks:

The order of the various steps described above can be changed. In particular, the average values α_k can be calculated after the security pattern of Fig. 9 is generated, and the steps for correcting the luminance, hue and saturation of the color shift are interchangeable.

The local averages α_k have been calculated as the averages over the individual characters of the security pattern. It is, however, also possible to use other averaging techniques. In particular, the security pattern can be processed by a low pass filter, where each point is e.g. replaced by a weighted average of itself and a number of neighboring points.

As already indicated, the security pattern may be non-binary and can e.g. consist of various gray levels, such as they may be used for representing anti-aliased characters.

In more general terms, the method described here starts from an original image and a security pat-

tern. It calculates local averages α_k of the values p_{ij}
of the security pattern, e.g. by averaging over the
bitmap of one character or by running the security pat-
tern through a low pass filter or by using interpolation
5   techniques of averaged values such as described by refer-
ence to Figs. 11 and 12. In particular, the local average
α_k of an area k can e.g. be calculated from

$$\alpha_k = \Sigma A_{k,ij} \cdot p_{ij} \qquad\qquad (7)$$

wherein A_k is a matrix of weights and Σ is the sum over
10 the points with indices i,j in said area k. In the exam-
ple above, the area k corresponds to one character bitmap
and $A_{k,ij} = 1/N_k$, wherein N_k is the number of points in
said area.

For at least some of the points of the origi-
15 nal image, the color C_{ij} of the original image is re-
placed by a color C'_{ij} using a function f:

$$C'_{ij} = f(C_{ij}, p_{ij}, \alpha_k),$$

wherein the function f depends on at least one local av-
erage α_k of an area k said point p_{ij} is located in.

20   Preferably, f should have the property that
if m and M are real numbers with $m < \alpha_k < M$, and wherein
$C_m = f(C_{ij}, m, \alpha_k)$ and $C_M = f(C_{ij}, M, \alpha_k)$, and if C_{ij}
lies within a color space with a Euclidean metric and we
define R_m as the Euclidean distance between C_m and C_{ij}
25 and R_M as the Euclidean distance between C_M and C_{ij}, then
for any value p_{ij} in the interval [m, M], the Euclidean
distance between C_{ij} and $f(C_{ij}, p_{ij}, \alpha_k)$ lies within the
interval $[0, \max(R_m, R_M)]$. In addition to this, f should
by continuous.

30   In other words, for pattern values that are
close to the local average, f should be such that the
color of the original image is changed only slightly. In
this way, the appearance of the protected image remains
globally identical to the appearance of the original im-
35 age.

If an averaging technique according to Eq.
(7) is used, f is preferably such that

$$\Sigma \ (A_{k,ij} \cdot f(C, \ p_{ij}, \ \alpha_k)) \approx C, \qquad (8)$$

wherein Σ is the sum over the points with indices i,j in said area k. This again ensures that the average color of a given local area k of the modified image is equal to
5 the average color of the same area of the original image.

Function f can be implemented algorithmically, e.g. by providing a chromatic shift for any given color C_{ij} and any local area k. The chromatic shift is given by two colors $C_b(C_{ij})$ and $C_f(C_{ij})$, wherein the
10 function f depends on said coverage-balanced chromatic shift in such a way that

$$f(C, \ p_{min}, \ \alpha_k) = C_b(C_{ij}) \ \text{and}$$
$$f(C, \ p_{max}, \ \alpha_k) = C_f(C_{ij}),$$

wherein p_{min} and p_{max} are the minimum and maximum possi-
15 ble pattern values p_{ij}. Between these values, f can e.g. be calculated by linear interpolation.

For calculating the chromatic shift for a given color C_{ij}, various methods can be used. As described above, it is e.g. possible to provide a reference
20 shift for one reference color K. The reference shift is given by two colors K_b and K_f, wherein K, K_b and K_f lie on a single line in an Euclidean additive color space and K is located in the center of K_b and K_f. The reference shift corresponds to the chromatic shift for color C_{ij} if
25 C_{ij} = K and α_k = $(p_{max} + p_{min})/2$. The reference shift can then be balanced e.g. using Eq. (2) above. Then, depending on the position of the colors K and C_{ij}, the values $C_b(C_{ij})$ and $C_f(C_{ij})$ can be derived by correcting hue, saturation and luminance, e.g. using Eqs. (3) - (5).
30

While there are shown and described presently preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and prac-
35 ticed within the scope of the following claims.

14

Claims

1. A method for generating a security document by applying a security pattern to an original image for generating a modified image, characterized in that

said security pattern comprises a plurality of points, wherein each of said points represents a pattern value p_{ij} and wherein local averages α_k are calculated from said pattern values for at least some areas k of said security pattern, and

wherein for at least some of the points in said security pattern the color C_{ij} of the corresponding point of the original image is replaced by a modified color C'_{ij} according to

$$C'_{ij} = f(C_{ij}, p_{ij}, \alpha_k),$$

wherein f is a function that depends on at least one local average α_k of an area k said point is located in.

2. The method of claim 1, wherein said function f is such that

if m and M are real numbers with $m < \alpha_k < M$, and wherein $C_m = f(C_{ij}, m, \alpha_k)$ and $C_M = f(C_{ij}, M, \alpha_k)$,

and if C_{ij} lies within a color space with a Euclidean metric and we define R_m as the Euclidean distance between C_m and C_{ij} and R_M as the Euclidean distance between C_M and C_{ij},

then for any value p_{ij} in the interval [m, M], the Euclidean distance between C_{ij} and $f(C_{ij}, p_{ij}, \alpha_k)$ lies within the interval $[0, \max(R_m, R_M)]$.

3. The method of one of the preceding claims, wherein said function $f(C_{ij}, p_{ij}, \alpha_k)$ is continuous in p_{ij}.

4. The method of one of the preceding claims, wherein said local averages α_k are calculated as a weighted sum

$$\alpha_k = \Sigma A_{k,ij} \cdot p_{ij}$$

wherein A_k is a matrix of weights and Σ is the sum over the points with indices i,j in said area k, and

wherein said function f has the property
that, for any color C of said original image in said area

$$\Sigma \ (A_{k,ij} \cdot f(C, \ p_{ij}, \ \alpha_k)) \ \approx \ C.$$

5. The method of claim 4, wherein all ele-
ments of said matrix A_k are equal to $1/N_k$, wherein N_k is
the number of points in said area.

6. The method of one of the preceding claims
wherein said security pattern is generated by repeti-
tively tiling a pattern element.

7. The method of one of the preceding claims,
wherein said security pattern comprises a plurality of
characters and wherein said local areas are rectangular
areas, each of said rectangular areas enclosing one char-
acter.

8. The method of one of the preceding claims
further comprising the step of providing a chromatic
shift for any given color C_{ij} and any local area k, said
chromatic shift being given by two colors $C_b(C_{ij})$ and
$C_f(C_{ij})$, wherein said function f depends on said cover-
age-balanced chromatic shift such that

$$f(C, \ p_{min}, \ \alpha_k) \ = \ C_b(C_{ij}) \ \text{and}$$
$$f(C, \ p_{max}, \ \alpha_k) \ = \ C_f(C_{ij}) \ \text{and}$$

for p_{min} and p_{max} being the minimum and maximum possible
pattern values p_{ij}.

9. The method of claim 8, wherein

$$f(C_{ij}, \ p_{ij}, \ \alpha_k) \ = \ C_b(C_{ij}) \cdot (p_{ij} - p_{min}) / (p_{max} - p_{min})$$
$$+ \ C_f(C_{ij}) \cdot (p_{max} - p_{ij}) / (p_{max} - p_{min})$$

10. The method of claim 9 further comprising
the steps of

choosing a reference shift for a reference
color K, wherein said reference shift is given by two
colors K_b and K_f and corresponds to said chromatic shift
for said color C_{ij} if $C_{ij} = K$ and $\alpha_k = (p_{max} + p_{min})/2$,

calculating said chromatic shift for any
other color C_{ij} from said reference shift by transforming
said two colors K_b and K_f as a function of color C_{ij} and
said local averages α_k.

11. The method of claim 10, wherein said reference color K and said two colors K_b and K_f are arranged on a line in an Euclidean, additive color space, wherein $K_b - K = K - K_f$ and wherein said step of calculating said
5 chromatic shift comprises the steps of
calculating first corrected colors K_b' and K_f' from

$$K_b' = K_b + d$$
$$K_f' = K_f + d$$

10 with

$$d = (K_f - K_b) \cdot (\alpha_k - (p_{max} - p_{min})/2)/(p_{max} - p_{min}),$$

and calculating said two colors $C_b(C_{ij})$ and $C_f(C_{ij})$ from said first corrected colors K_b' and K_f', said reference color K and said color C_{ij}.

15 12. The method of one of the claims 10 or 11 comprising the step of calculating said two colors $C_b(C_{ij})$ and $C_f(C_{ij})$

by correcting the luminance of the chromatic shift according to the luminance difference between the
20 reference color K and the color C_{ij}, and/or

by correcting the hue of the chromatic shift according to the hue difference between the reference color K and the color C_{ij}, and/or

by correcting the saturation of the chromatic
25 shift according to the saturation difference between the reference color K and the color C_{ij}.

13. The method of claim 11 or 12 comprising the step of correcting a CIE-Lab luminance difference between said two colors $C_b(C_{ij})$ and $C_f(C_{ij})$ to make it
30 equal to the CIE-Lab luminance difference between said two colors K_b and K_f.

14. The method of one of the preceding claims wherein said pattern values are binary having values of 0 and 1, wherein for a pattern value of 0 the color C_{ij} of
35 the corresponding point of the original image is shifted in a first direction and for a pattern value of 1 the color C_{ij} of the corresponding point of the original im-

age is shifted in a second direction, and in particular wherein, in a given Euclidean color space, said first direction is opposite to said second direction.

15. The method of one of the preceding claims wherein said original image is a holder's photograph on an identity document.

16. The method of one of the preceding claims comprising the step of printing the modified image on a continuous-tone printer.

17. A security document obtainable by the method of one of the preceding claims.

18. The security document of claim 17, wherein said security document is a driving license.

19. The security document of one of the claims 17 or 18, wherein said pattern is a text representing information that is also elsewhere visible on said document, and in particular wherein said text is at least partially encrypted.

Fig. 2

$\alpha C_f + (1-\alpha) C_b$

C

Fig. 1

"T E X"

Fig. 3

$$P_k = 70$$
$$P_t = 16 \times 10 = 160$$
$$\alpha = P_k / P_t = 70/160$$

Fig. 4

$$d = D \cdot (\alpha_k - 0.5)$$

Fig. 5

Fig. 6

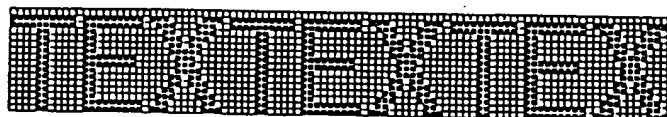

Fig. 7

Fig. 9

Fig. 8

$\{K'_b, K', K'_f\}T$ $\{K'_b, K', K'_f\}E$

Fig. 10

$\{K'_b, K', K'_f\}E$ $\{K'_b, K', K'_f\}X$
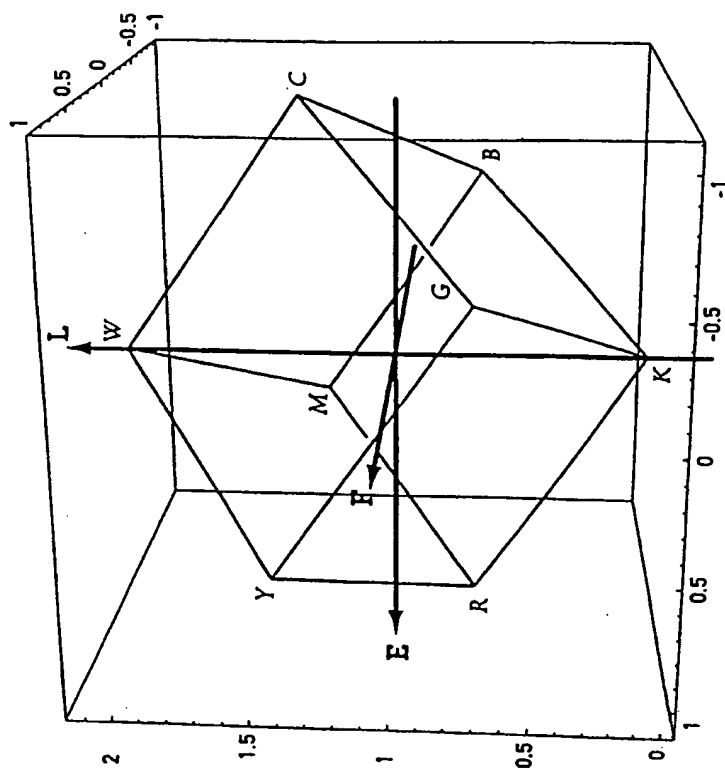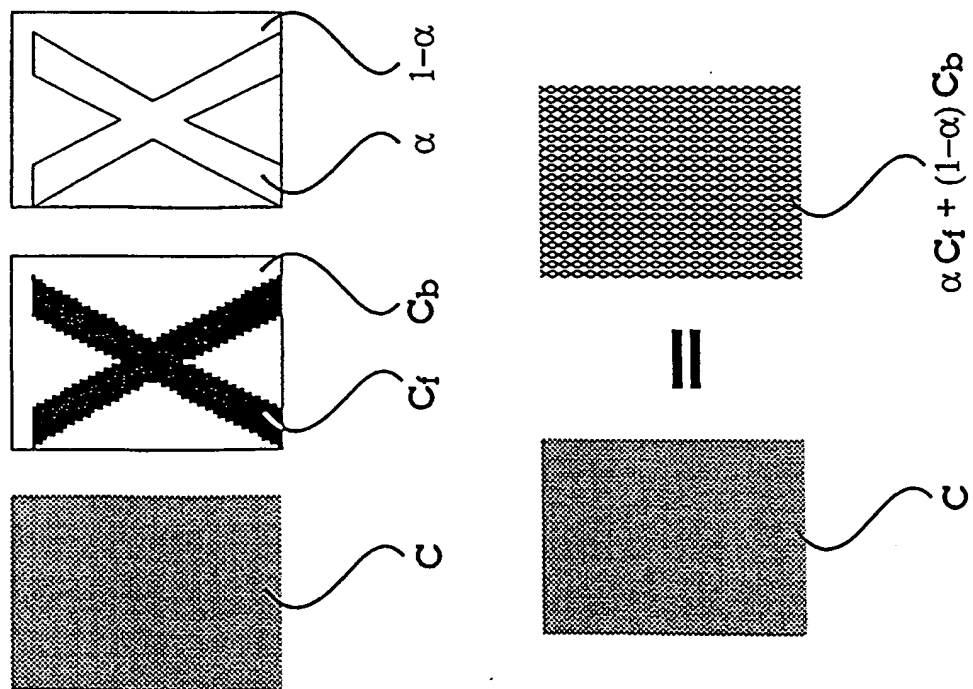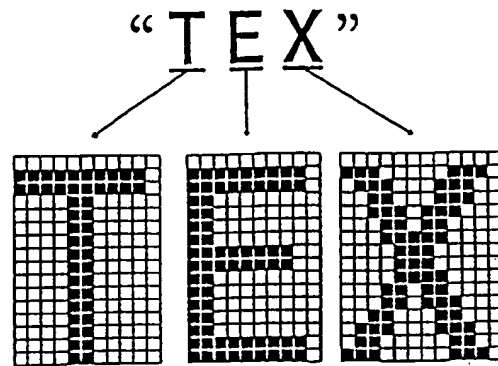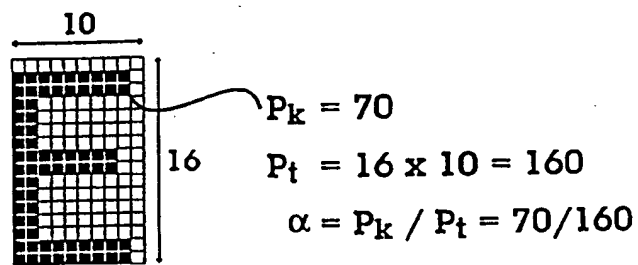
$\{K'_b, K', K'_f\}T$ $\{K'_b, K', K'_f\}E$
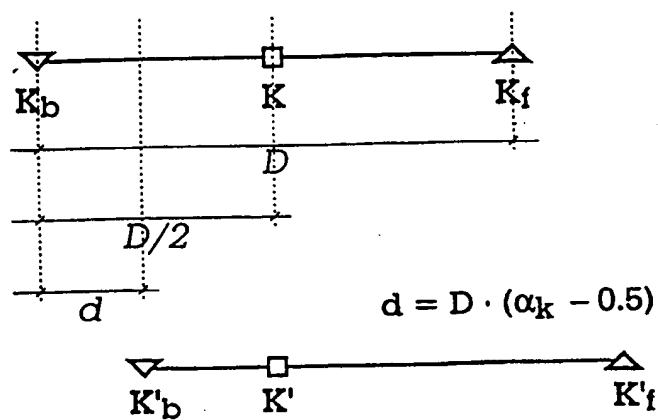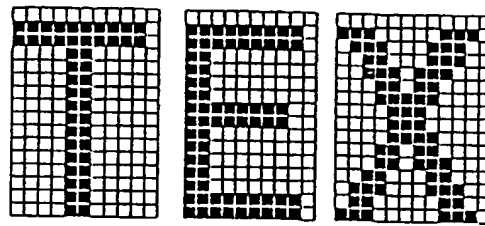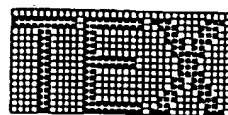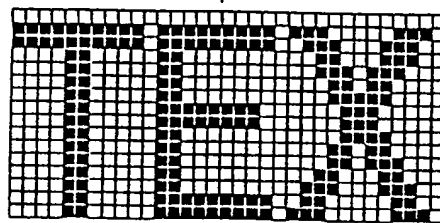
Fig. 11
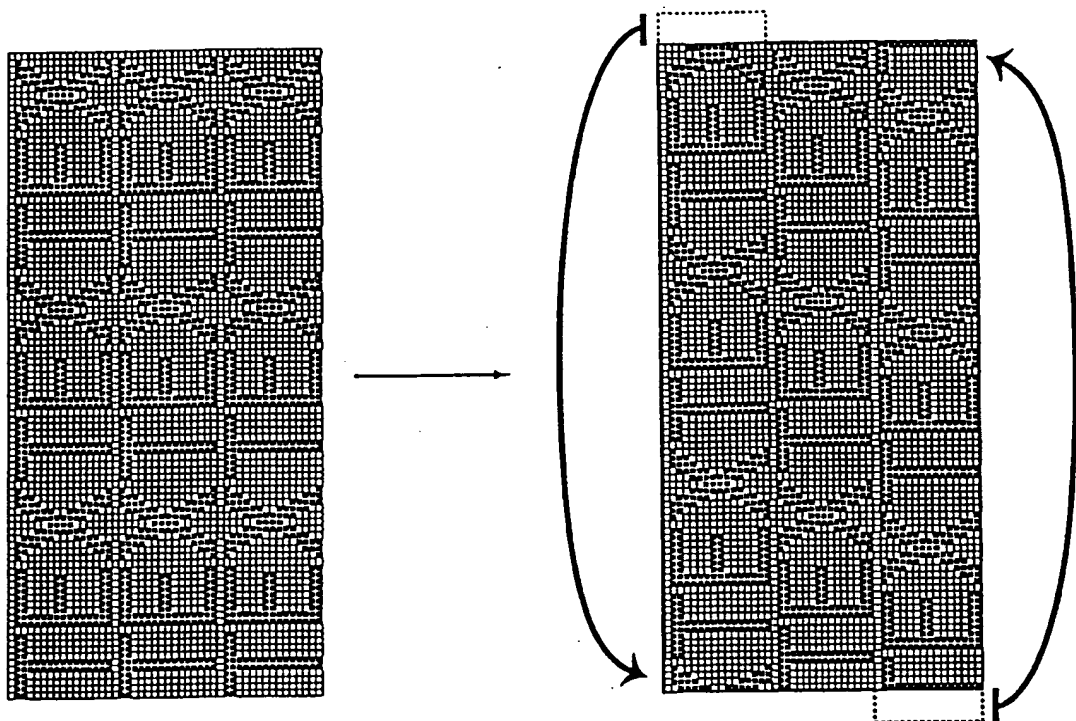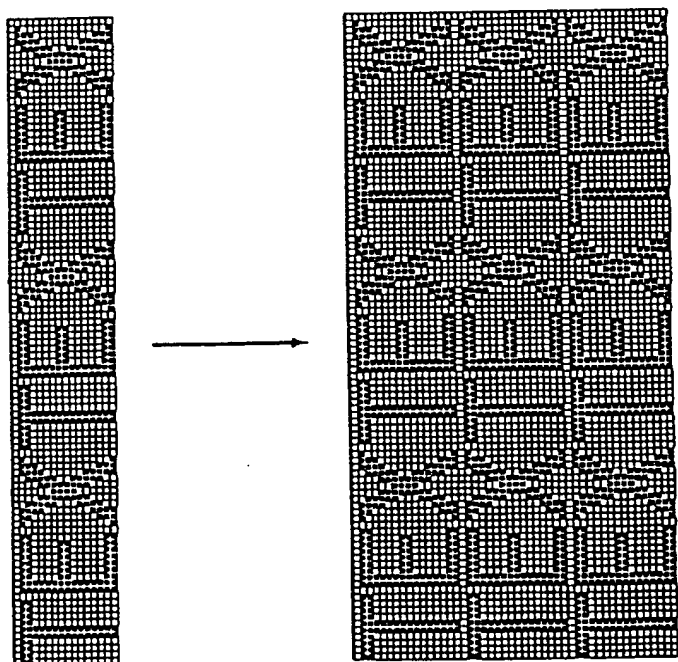
$\{K'_b, K', K'_f\}TE =$
$$b/(a+b) \{K'_b, K', K'_f\}T + a/(a+b) \{K'_b, K', K'_f\}E$$
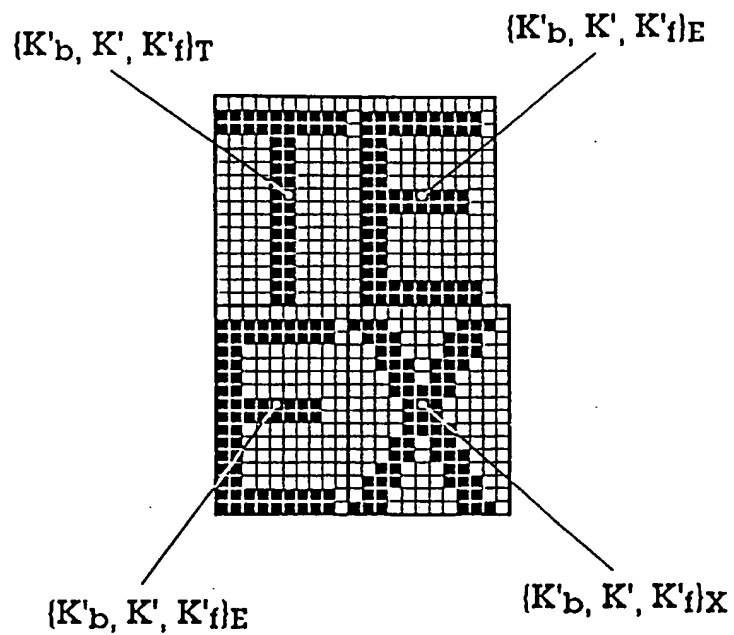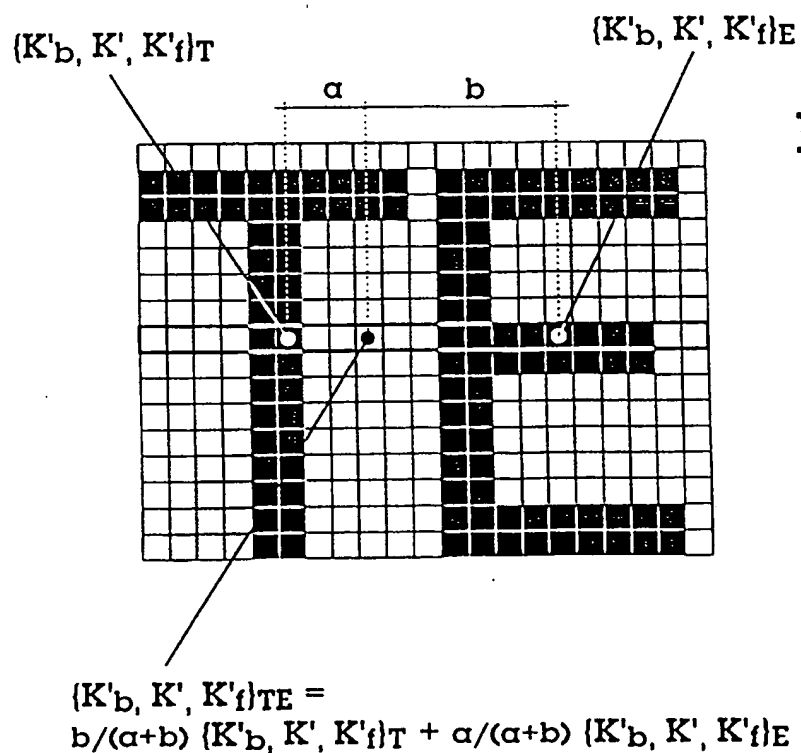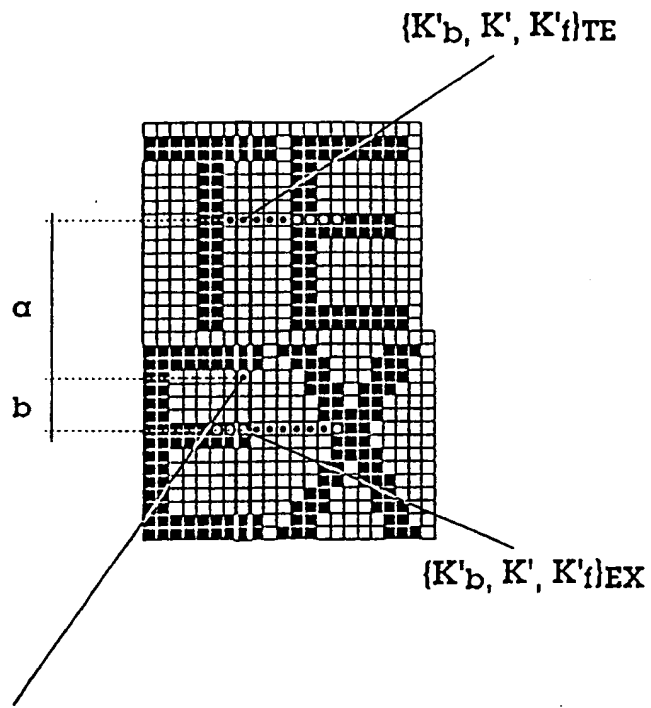
$\{K'_b, K', K'_f\}_{TE}$

Fig. 12

$$\{K'_b, K', K'_f\} =$$
$$b/(a+b) \{K'_b, K', K'_f\}_{TE} + a/(a+b) \{K'_b, K', K'_f\}_{EX}$$

$\{K'_b, K', K'_f\}_{EX}$
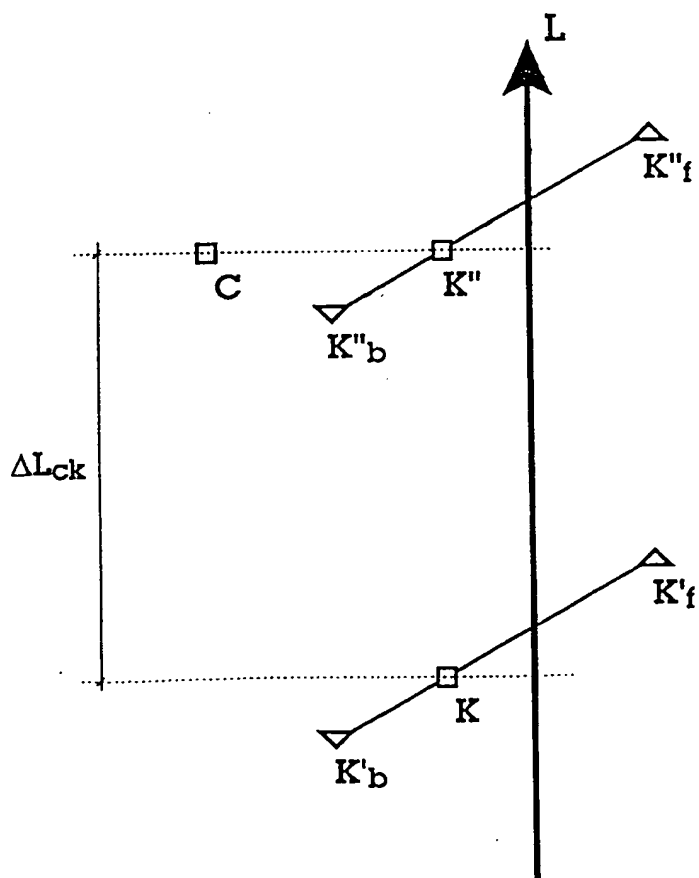
Fig. 13
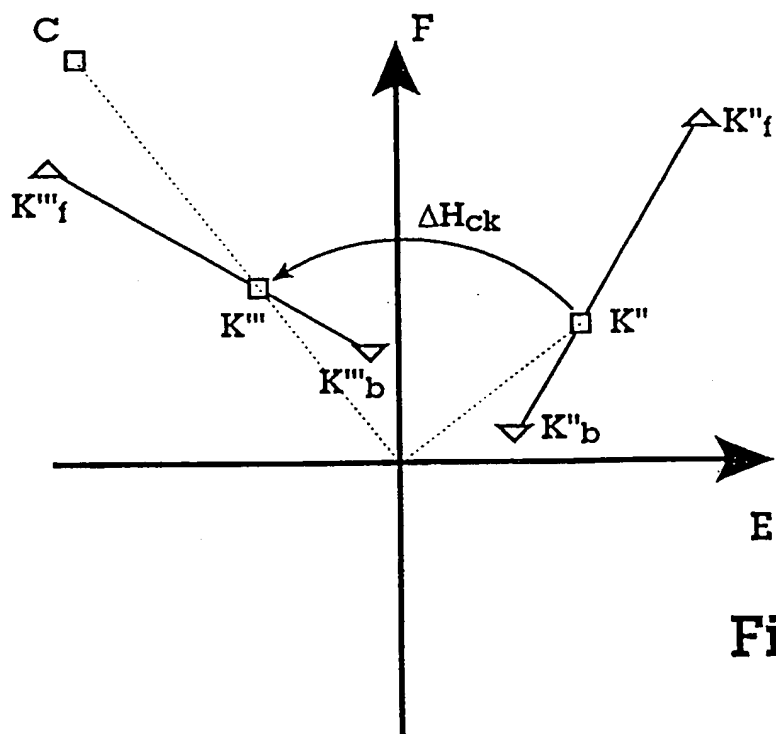
Fig. 14
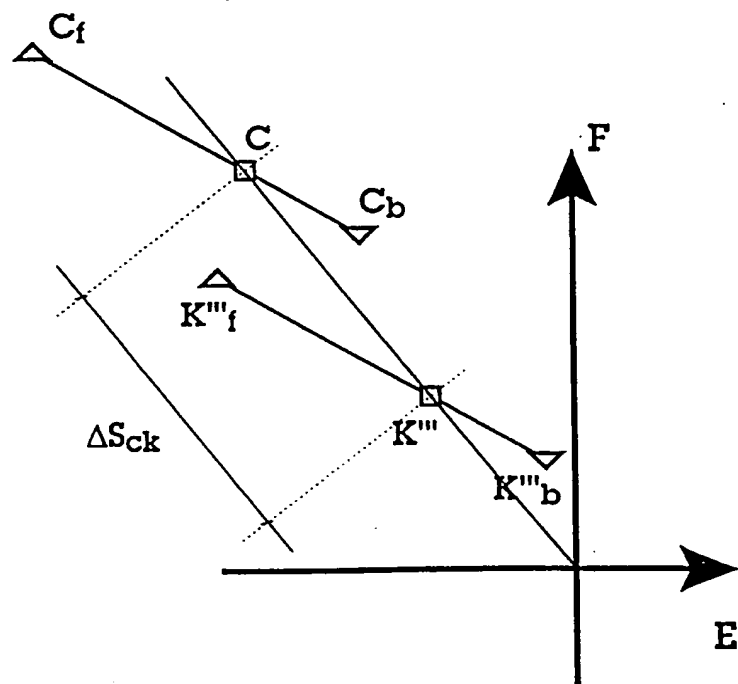
Fig. 15
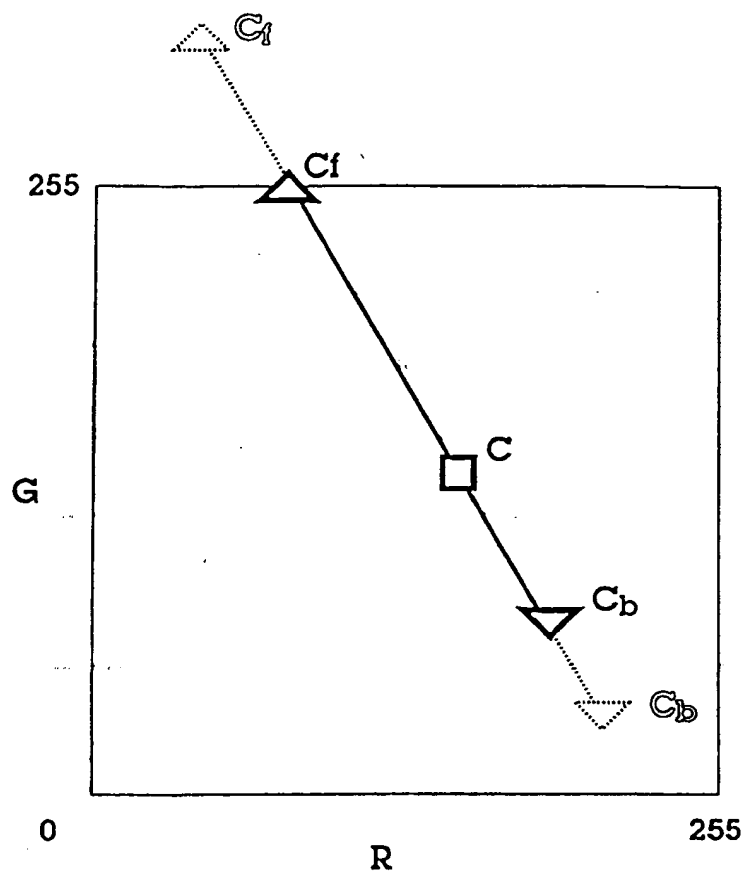
Fig. 16

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   H04N1/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7   H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 642 060 A (TOKYO SHIBAURA ELECTRIC CO) 8 March 1995 (1995-03-08) the whole document	1
A	EP 0 590 884 A (CANON KK) 6 April 1994 (1994-04-06) column 11, line 34 -column 14, line 4 column 29, line 40 - line 49	1
A	EP 0 705 022 A (CANON KK) 3 April 1996 (1996-04-03) abstract	1

-/--

[X] Further documents are listed in the continuation of box C.   [X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 October 2000	17/10/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Hazel, J

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Intern⋯ ⋯al Application No

PCT/1B 00/00984

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	KUTTER M ET AL: "DIGITAL WATERMARKING OF COLOR IMAGES USING AMPLITUDE MODULATION" JOURNAL OF ELECTRONIC IMAGING,US,SPIE + IS&T, vol. 2, no. 7, page 326-332 XP000750388 ISSN: 1017-9909	

1

INTERNATIONAL SEARCH REPORT

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0642060	A	08-03-1995	DE	69417661 D	12-05-1999
			DE	69417661 T	11-11-1999
			JP	7123244 A	12-05-1995
			KR	161366 B	20-03-1999
			US	5652626 A	29-07-1997
EP 0590884	A	06-04-1994	JP	6113109 A	22-04-1994
			JP	6113110 A	22-04-1994
			JP	6113112 A	22-04-1994
			JP	6113113 A	22-04-1994
			CA	2106706 A	29-03-1994
			DE	69319290 D	30-07-1998
			DE	69319290 T	12-11-1998
			US	5557412 A	17-09-1996
			US	5696594 A	09-12-1997
EP 0705022	A	03-04-1996	JP	8101755 A	16-04-1996
			US	5661574 A	26-08-1997
			US	5832186 A	03-11-1998